Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

Course Code: CH201

Course Name:CHEMICAL PROCESS CALCULATIONS

Max. Marks: 100 Duration: 3 Hours

(Psychrometric charts, compressibility charts allowed)

PART A

Answer any two full questions, each carries 15 marks Marks

1 a) Differentiate between unit operations and unit processes. (5)

b) A solution of potassium chloride in water contains 384 g KCl per litre of solution at 300 K. The specific gravity of the solution is 1.6. Determine the following: (10)
i) The concentration in weight percent ii) The mole fraction of KCl.
iii) The molarity of the solution iv) The molality of the solution

2 a) Using Nelson-Obert chart, estimate the volume occupied by 1 kg water vapour at 17 bar and 500 K; given the critical pressure and temperature of water as 221.2 bar and 647.3 K respectively. Compare the result with the volume calculated using the ideal gas equation. (8)

b) A natural gas has the following composition by volume: CO_2 0.8%, N_2 3.2%, and CH_4 96.0%. Calculate: (7)
i) The composition in weight percent ii) The average molecular weight
iii)The density at standard conditions in kg/m^3

3 a) A water soaked cloth is dried from 45% to 9% moisture on wet basis. Find the weight of water removed from 2000kg of dry fabric. (5)

b) Determine the molar volume of gaseous methane at 300K and 600 bar by ideal gas equation ,The Vander Waals equation given that a = 0.2285 N m^4/mol^2; b = 4.27 x 10^{-5} m^3/mol & Redlich-Kwong equation given that T_c = 191.1 K and P_c = 46.4 bar. (10)

PART B

Answer any two full questions, each carries 15 marks

4 a) The dry bulb temperature and dew point of air sample at 101.3 kPa are 328 K and 308 K respectively. Calculate the following using psychometric chart: (9)
i) The absolute humidity, molal humidity and percent saturation
ii) The partial pressure of water vapour and relative saturation
iii) The wet bulb temperature

b) Ethyl ether and water are charged into a still in the weight ratio 3:1 and allowed to boil. Ether and water are immiscible. The temperature of the contents is maintained at 303 K at which vapour pressures of the pure liquids are 4.2kPa for water and 80kPa for ether. Calculate the pressure inside the still &the composition of the residual liquid when half the original mixture is vaporized. (6)

5 a) An evaporator is fed continuously with 50000kg/hr of a solution containing 10% NaOH, 10% NaCl, and the rest water by weight. During evaporation,water is removed as vapour and salt NaCl precipitates as crystals and is removed by filtration. The concentrated liquor leaving the evaporator contains 50% NaOH, 2% (8)

NaCl and the rest water, determine the mass of water evaporated per hour, the mass of salt precipitated per hour and the mass of concentrated liquor produced per hour.

b) Desalination of brackish water is achieved by evaporation. A fraction of the feed water is sent through an evaporator and the other part is bypassed. The fraction bypassed and the pure water leaving the evaporator are mixed together to give the desalinated water of desired quality. If the feed has 400ppm of salt, and the salt content in the water used for irrigation is to be limited to a maximum of 50 ppm, what fraction of the feed water is to be sent through the evaporator? (7)

6 a) A stream of gas at 302 K and 100 kPa, 50% saturated with water vapour is passed through a drying tower where 90% of the water vapour is removed. For $100m^3$ of gas admitted through the tower, how many kilograms of water is removed? The vapour pressure of water at 302 K is 4.0kPa. (4)

b) The vapour pressure of ethyl ether at 273 K is 25 kPa and its latent heat of vaporization is 4.185×10^2 kJ/kg. Estimate the vapour pressure at 293 K and 308 K. (3)

c) A batch of leather leaving a dryer weighs 1000 kg and contains 5% moisture. During drying the leather loses 50% of its original weight. Determine the following: (8)

i) The moisture content of the leather entering the dryer on a dry basis
ii) The amount of moisture removed per kg of bone dry leather
iii) Water removed as percent of the original water present

PART C

Answer any two full questions, each carries 20 marks

7 a) When coal containing 74% C, 14.9% H and 11.1% ash is burned, it gives a flue gas containing 12.5% CO_2, 1.0% CO, 1.5% O_2 and 85% N_2 on dry basis. Determine the mass of coal fired in kg/kmol of dry flue gas, the percent excess air used&the amount of air supplied kg/kg of coal burned. (10)

b) HCl is oxidized to Cl by air in presence of a catalyst. Air is supplied 30% in excess of the theoretical requirement and the oxidation of the acid is 60% compete. Calculate the ratio of acid to air on a weight basis, the composition of the gases leaving the reactor on a weight basis. (10)

8 a) Write down the energy balance for non-flow processes and flow processes. (10)

b) Using Hess's law, calculate the heat of formation of chloroform($CHCl_3$) (10)

$$CHCl_3(g) + 0.5O_2 + H_2O(l) \rightarrow CO_2(g) + 3HCl(l) \qquad \Delta H^0_{298} = -281.67 \text{ kJ}$$
$$H_2(g) + 0.5O_2(g) \rightarrow H_2O(l) \qquad \Delta H^0_{298} = -285.84 \text{ kJ}$$
$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^0_{298} = -393.51 \text{ kJ}$$
$$0.5H_2(g) + 0.5Cl_2(g) \rightarrow HCl(g) \Delta H^0_{298} = -92.311 \text{ kJ}$$

9 a) Methanol vapour can be converted into formaldehyde by the following reaction scheme: (10)

$$CH_3OH + 0.5\,O_2 \rightarrow HCHO + H_2O$$
$$CH_3OH \rightarrow HCHO + H_2$$

The fresh feed to the process was 0.5 kmol/hr of O_2 and an excess methanol. All of the O_2 reacts in the reactor. Formaldehyde and water are removed from the product stream first, after which hydrogen is removed from the recycled methanol.

The recycle flow rate of methanol is 1 kmol/hr. the ratio of methanol reacting by decomposition to that of oxidation was 3. Calculate fresh feed rate of methanol, the single pass conversion of methanol& the amount of hydrogen produced.

b) For the following reaction the standard heat of reaction at 300 K is -164.987 kJ. (10)

$$\mathbf{CO_2(g) + 4H_2(g) \rightarrow 2H_2O(g) + CH_4(g)}$$

The constants in the heat capacity (J/mol K) equation are given below:

	α	**β**	**γ**
CO_2	26.75	42.26×10^{-3}	-14.25×10^{-6}
H_2	26.88	4.35×10^{-3}	-0.33×10^{-6}
H_2O	29.16	14.49×10^{-3}	-2.02×10^{-6}
CH_4	13.41	77.03×10^{-3}	-18.74×10^{-6}

Calculate the standard heat of reaction at 775 K.

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